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Westerman et al.

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(54) **METHOD AND APPARATUS FOR  
INTEGRATING MANUAL INPUT**

Sarah A. Douglas and Anant Kartik Mithal, *The Ergonomics  
of Computer Pointing Devices* (1997).

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(57) **ABSTRACT**

Apparatus and methods are disclosed for simultaneously tracking multiple finger and palm contacts as hands approach, touch, and slide across a proximity-sensing, compliant, and flexible multi-touch surface. The surface consists of compressible cushion, dielectric, electrode, and circuitry layers. A simple proximity transduction circuit is placed under each electrode to maximize signal-to-noise ratio and to reduce wiring complexity. Such distributed transduction circuitry is economical for large surfaces when implemented with thin-film transistor techniques. Scanning and signal offset removal on an electrode array produces low-noise proximity images. Segmentation processing of each proximity image constructs a group of electrodes corresponding to each distinguishable contact and extracts shape, position and surface proximity features for each group. Groups in successive images which correspond to the same hand contact are linked by a persistent path tracker which also detects individual contact touchdown and liftoff. Combinatorial optimization modules associate each contact's path with a particular fingertip, thumb, or palm of either hand on the basis of biomechanical constraints and contact features. Classification of intuitive hand configurations and motions enables unprecedented integration of typing, resting, pointing, scrolling, 3D manipulation, and handwriting into a versatile, ergonomic computer input device.

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#### Related U.S. Application Data

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(51) Int. Cl.<sup>7</sup> ..... **G09G 5/00**

(52) U.S. Cl. .... **345/173**

(58) Field of Search ..... **345/173, 174,  
345/178, 184, 156, 158**

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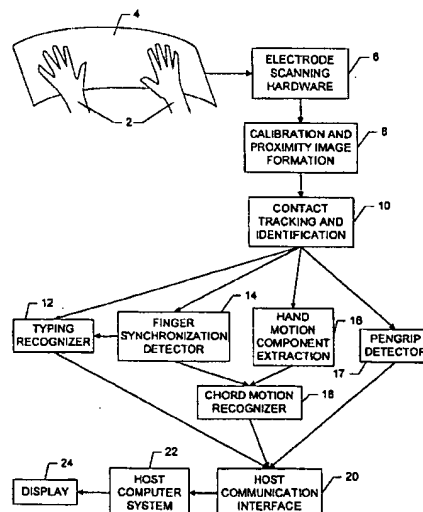
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**118 Claims, 45 Drawing Sheets**



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TITLE: Method and apparatus for integrating manual input

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To still further achieve the objects, the present invention comprises a multi-touch surface apparatus for sensing diverse configurations and activities of touch devices and generating integrated manual input to one of an electronic or electro-mechanical device, the apparatus comprising: an array of one of the proximity sensing devices described above; a dielectric cover having symbols printed thereon that represent action-to-be-taken when engaged by the touch devices; scanning means for forming digital proximity images from the array of sensing devices; calibrating means for removing background offsets from the proximity images; recognition means for interpreting the configurations and activities of the touch devices that make up the proximity images; processing means for generating input signals in response to particular touch device configurations and motions; and communication means for sending the input signals to the electronic or electro-mechanical device.

To still even further achieve the objects, the present invention comprises a method for choosing what kinds of input signals will be generated and sent to an electronic or electro-mechanical device in response to tapping or sliding of fingers on a multi-touch surface, the method comprising the following steps: identifying each contact on the surface as either a thumb, fingertip or palm;

measuring the times when each hand part touches down and lifts off the surface;  
forming a set of those fingers which touch down from the all finger floating state before any one of the fingers lifts back off the surface; choosing the kinds of input signals to be generated by further distinctive motion of the fingers from the combination of finger identities in the set; generating input signals of this kind when further distinctive motions of the fingers occur;  
forming a subset any two or more fingers which touch down synchronously after at least one finger has lifted back off the surface; choosing a new kinds of input signals to be generated by further distinctive motion of the fingers from the combination of finger identities in the subset; generating input signals of this new kind when further distinctive motions of the fingers occur; and continuing to form new subsets, choose and generate new kinds of input signals in response to liftoff and synchronous touchdowns until all fingers lift off the surface.

processing means for generating input signals in response to particular touch device configurations and motions; and

92. The method of claim 91, wherein production of discrete key symbols or mouse button click commands from single finger taps or finger chord taps is accompanied by transmission of activation signals to a light or sound feedback generating device.

105. A method for choosing what kinds of input signals will be generated and sent to an electronic or electro-mechanical device in response to tapping or sliding of fingers on a multi-touch surface, the method comprising the following steps:

113. The method of claim 105, wherein generation of input signals is accompanied by generation of activation signals to a light or sound generating feedback device, and wherein the activation signals depend upon the kinds of input signals currently selected.